Disturbance of Soil Organic Matter and Nitrogen Dynamics: Implications for Soil and Water Quality (CS-1114D-00)

C.T. Garten, Jr., and R. Washington-Allen, ORNL Team 2

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1. ACCOMPLISHMENTS SUMMARY

During the third quarter of FY03, ORNL Team 2

- revised a manuscript and submitted it for publication to *Applied Soil Ecology*,
- completed a draft manuscript on modeling soil quality thresholds to ecosystem recovery,
- completed post-disturbance soil sampling at the K-11 experimental site,
- completed a summary of data for all soil samples collected at Fort Benning by ORNL Team 2, and
- began preparing electronic files (metadata and data files) for the transfer of field and laboratory data to the SEMP Data Repository.

2. BACKGROUND

2.1 Progress with manuscripts

During this report period, progress was made by ORNL Team 2 on three manuscripts for publication in peer-reviewed journals.

The first manuscript is titled "Effect of military training on indicators of soil quality at Fort Benning, Georgia". The manuscript was accepted for publication in the journal *Ecological Indicators*. Page proofs were received and returned to the publisher. We expect the article to be published in the second half of 2003.

The second manuscript is titled "Land cover differences in soil carbon and nitrogen at Fort Benning, Georgia". The manuscript was revised during this report period and submitted for publication to the journal *Applied Soil Ecology*. We are currently awaiting the outcome of the peer review process.

The third manuscript is titled "Modeling soil quality thresholds to ecosystem recovery at Fort Benning, Georgia". This manuscript describes simple models of soil carbon and nitrogen dynamics to predict nutrient thresholds to ecosystem

recovery on degraded soils at Fort Benning, Georgia. The model calculates aboveground and belowground biomass, soil carbon inputs and dynamics, soil nitrogen stocks and availability, and plant nitrogen requirements. A threshold is crossed when predicted soil nitrogen supplies fall short of nitrogen required to sustain biomass growth at a specified rate of recovery. Thresholds to ecosystem recovery predicted by the model should not be interpreted independent of a specified recovery rate. Four factors were important to development of thresholds to recovery: (1) initial amounts of aboveground biomass, (2) initial soil carbon stocks (i.e., soil quality), (3) relative growth rates of biomass, and (4) soil sand content. Initial soil carbon stocks determined predicted patterns of recovery by both old field and forest ecosystems. Forests and old fields on soils with varying sand content had different predicted thresholds to recovery. Soil carbon stocks at barren sites on Fort Benning generally lie below predicted thresholds to 100% recovery of theoretical desired future ecosystem conditions (18000 and 360 g aboveground biomass m^{-2} for forests and old fields, respectively). Calculations with the model indicate that recovery of vegetation on barren sites to some level below the desired future condition is possible at growth rates used in the model, but 100% recovery to desired future conditions, without crossing a nutrient threshold, is slow for forests. Predicted thresholds to ecosystem recovery were less on soils with more than 70% sand content. The lower thresholds for old field and forest recovery on more sandy soils are apparently due to higher relative rates of net soil nitrogen mineralization in more sandy soils. Calculations with the model indicate that a combination of desired future conditions, initial levels of soil quality (defined by soil carbon stocks), and the rate of biomass accumulation determines the predicted success of ecosystem recovery on disturbed soils.

2.3 Field work at K-11 experimental site

During this report period, ORNL Team 2 completed post-disturbance soil sampling at the experiment in the K-11 training compartment. Soil sampling was conducted in mid-June and coordinated with plant sampling by ORNL Team 1 (Dale et al., CS-1114C-99). ORNL Team 2 collected paired soil cores (to a 30 cm soil depth) at seven disturbed locations and seven control points. Samples were also collected for analysis of potential net soil nitrogen mineralization inside and outside the areas of soil disturbance. John Dilustro from SREL (Collins et al., CS-1114E-00) placed sampling points for soil respiration at some of the same locations where ORNL Team 2 collected soil samples. The soil samples were returned to ORNL and will be prepared for analysis of total soil carbon and nitrogen concentrations and stocks, carbon and nitrogen in particulate organic matter and mineral-associated organic matter, and soil nitrogen availability. We will test for differences in measures of soil quality between disturbed soils and their controls using analysis of variance. Data

collected in the post-disturbance environment will also be compared with data from pre-disturbance soil sampling conducted in 2001 at the same location.

2.3 Data summarization

Since the last quarterly report, ORNL Team 2 has completed a summarization of measures of soil quality for over 100 sites under perennial vegetation and 20 sites where there has been recent soil disturbance at Fort Benning. Simple descriptive statistics have been used to summarize measures of soil quality (e.g. soil carbon and nitrogen levels and soil nitrogen availability) and the following comparisons have been completed:

(1) comparisons of clear-cut and control forest soils at various times (1, 6, or 11 years) after clear-cutting,
(2) comparisons of riparian and upland sampling sites in the K-11 training compartment in April and October 2001,
(3) comparisons along a chronosequence of longleaf pine stands (10, 12, 56, 70, 75, and 82 year old stands),
(4) comparisons of different land cover categories (e.g., barren sites, old-fields, pine forests, and deciduous forests),
(5) comparisons of young (n = 11) and mature (n = 16) pine stands, and
(6) comparisons of old field and forest sites on soils with differing sand content.

One of the interesting patterns to emerge from these comparisons is the influence of sand content on measures of soil quality. Sand content in 129 soil samples collected at Fort Benning ranged from 12 to 95%. The mean sand content was 70% and two-thirds of the samples collected had a sand content that exceeded the mean. For the purpose of comparisons, each soil sample was binned into one of two categories (i.e., “less sandy” or “more sandy”) based on whether the sand content was less than or more than 70%. Old field and forest sites on less sandy soils have significantly greater soil carbon and nitrogen stocks than those on more sandy soils. However, the mean potential net soil nitrogen mineralization rate, expressed on an annual basis, is greater for soils with more than 70% sand content. Forests and old fields on soils with differing sand content had different predicted thresholds to ecosystem recovery.

Last, ORNL Team 2 has begun preparing a summary data set for transfer to the SEMP Data Repository in the second half of 2003. This file will contain data for soil samples collected at Fort Benning, by ORNL Team 2 prior to December 31, 2002 (and not already present in the repository). The data will be transferred as an ASCII file upon completion of the metadata document that is currently in progress.

3. MILESTONE PROGRESS

ORNL Team 2 had a single milestone for this report period (with a deadline of June 2003). The milestone was "complete an analysis of soil carbon and nitrogen (including soil nitrogen dynamics) for all soil samples taken at Fort Benning prior to December 31, 2002". This milestone has been completed (see section 2.3 above).

Additional progress was made on a deferred milestone related to studies of net soil nitrogen mineralization in collaboration with SREL (Collins et al., CS-1114E-00). Chuck Garten and John Dilustro met on June 19, 2003, to discuss their respective measurements of net soil nitrogen mineralization. Robert Washington-Allen also met with Hugh Westbury on June 19th and they discussed issues related to remote sensing of landscape metrics at Fort Benning. Chuck and John noted some encouraging aspects to their independent data sets dealing with soil nitrogen availability. First, their measures of potential net nitrogen mineralization from laboratory incubations of Fort Benning soils are in reasonable agreement. Second, patterns of higher potential net soil nitrogen mineralization on more sandy soils appear to be consistent between the two data sets. Chuck Garten agreed to analyze approximately 100 soil samples for John Dilustro for total soil carbon and nitrogen using ORNL's LECO CN-2000 elemental analyzer. This will enable John to complete some calculations of soil nitrogen availability that are not currently possible with his existing data.